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of energy for work constantly diminishes; in other words, *its ability to embody new forms and ideas is gradually being reduced.* Spurts of new life and the formation of new combinations indicate desperate efforts on the part of the actual to extend its hold upon the ideal; but with the eventual cessation of work, foreshadowed by the so-called law of degeneration, the dominion of matter over form will come to an end, and the realm of possibilities will no longer suffer encroachment from the actual.

In line with this tendency are all the noblest aspirations of man as embodied in art, in religion, and in philosophy. In these, the soul proclaims itself an exile in the actual and voices a profound yearning to escape from the immediate in time and in space. Romanticism, then, as we have defined it, is not by any means an isolated movement. Philosophy and poetry constitute preëminent instances of the soul liberating itself from fact under the stimulus, in the one case, of intellectual and in the other of esthetic imagination. Even science, as we noted above, is not a mirror of fact, but an intellectual embroidery upon it. And as philosophy expresses the romanticism of the intellect, so does the attitude of faith represent the romanticism of the will. For what is this undying optimism in the face of failure, this pathetic devotion to hopeless causes, this faith in the eventual doing of justice when injustice rules unchecked, this belief in human beings and confidence in their unlimited progress, but a vast construction of the moral imagination upon the very facts of failure?

In the long run, life can not be left wholly out of account; after all, life is one of the many dreams and the actual world one of the infinite possible worlds. We should therefore school our minds to conceive the actual *sub specie possibilitatis*—to use it indeed as a stepping-stone into the domain of possibility. For the enlightened soul inhabits a world whose area embraces the actual but extends far beyond it into the subsistent, and its home is the entire universe of being.

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RELATIVITY, OLD AND NEW[1]

IN the presentation of a scientific theory for philosophical consideration, it is of primary importance that the fundamental bases of the theory be brought prominently, and indeed unequivocally to the fore, and that the points at which it departs in its vital essentials from previously held theories relating to the same phenomena stand forth in unmistakable relief. From this standpoint I can not but take exception to Mr. Turner's presentation, as well as to some of his conclusions.

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[1] Certain objections to J. E. Turner's article "Some Philosophic Aspects of Scientific Relativity," this JOURNAL, Vol. XVIII, No. 8.

In his second paragraph Mr. Turner wisely says " . . . the term 'relativity' itself accounts for much of the prevailing confusion," and further, "Even its widest later applications are concerned only with the relative velocities of systems and observers, and with the mathematical and other scientific (but not philosophic) implications of these. . . . The theory has . . . no bearing on the subjectivity of Time and Space." The first quotation would suggest that an explanation of the term "relativity" in its application under discussion is desirable, and this I shall endeavor to supply. The second is true only if "philosophic" is used in a very narrow sense. Philosophy, certainly if it "holds an inalienable lien on the whole of experience" is concerned with other aspects of time and space than their subjectivity and objectivity. While relativity may throw no additional light on the question of the degree of objectivity possessed by the metrical time and space which are mathematically treated, it introduces changes in our ideas as to the relations between them, to motion, and to things in time and space, which, even if not "revolutionary," are profoundly different from the classical conceptions. Revolutionary is an hyperbolical word, but the theory of the relations between space and time required by modern physics must command philosophical attention, though it be characterized by a more modest adjective.

The idea of "relativity" in physics is by no means modern, but has been assumed in Newtonian mechanics almost axiomatically in the case of uniform motion. This "Newtonian Relativity" is the relativity of the "man in the street," and in everyday language is nothing more than the statement that if a person walks four miles per hour from the rear platform to the front platform, of a trolley car running twenty miles an hour, he will cover ground at the rate of twenty-four miles an hour; and further, if a boy standing on the track in front of the car throws a stone at a speed of one hundred miles an hour, it will hit the passenger at the speed of one hundred and twenty-four miles an hour. This seems axiomatic to the non-scientifically inclined, and in the language of physics defines space as a region in which Euclidean geometry is valid. In such a space figures may be moved about and rotated without change of size or shape, either while moving, or after having changed their relative positions; velocities are directly additive, and by combining a sufficient number of finite velocities, we may *exceed any specified velocity.* If we have a record of the motions of our passenger in the trolley car relative to the car (as for instance the spots that he tapped on the floor with his cane, which he is in the habit of swinging every second as he walks) we can obtain a record of his positions relative to the track by adding to the distance of each spot from the rear platform, the quantity obtained by multiplying the time of that spot by the velocity of the car, and laying off the total distance so computed from the position of the rear platform when the car started. If we denote the distance from the rear platform of the car by x' and that from the station by x we find that $x' = x - vt$ (1) where v is the velocity of the car. The position of the passenger between the rails, and the height above the rails are not affected by the motion of the car, and there is no discrepancy between the passenger's watch and the clock in the station, provided that they agreed at the start. These facts are described by the equations $y' = y$, (2), $z' = z$ (3), and $t' = t$ (4). The important features of this transformation, for our present discussion are:

(*a*) Distances are unaltered.
(*b*) Directions are unaltered.
(*c*) Velocities are directly additive.
(*d*) *The time is entirely independent of the space transformation.*
(*e*) No forces are introduced in one system that were not present in the other.

It seems inherent to our sense of physical things that they should be describable from two systems of reference, *i.e.*, from the car and from the ground, in such a way that certain properties which we feel to be fundamental should remain unaltered in the two descriptions. In the transformation from one system to another which we have just described, *i.e.*, one in which the two systems of reference have a uniform velocity relative to each other, these properties are: length, direction, mass and force. It is important to notice that no velocity is invariant. The velocity with which the passanger is covering the ground is the sum of the speed with which he walks in the car, and the speed of the car.

The above discussion covers "Newtonian relativity" in its essentials. It is something so familiar that we almost instinctively feel it, and the quantities that it leaves invariant we have hitherto regarded as fundamental in physics, and, in fact, as "objective" in the same sense that "things" and any relations between things are objective. So deeply was the idea of the invariance of these quantities embedded in our physical concepts that when new forces were introduced in cases in which the motion was not uniform, we did not regard it as a violation of the principle, and we called such forces "inertia forces," although the question, "Uniform relatively to what?" was lightly avoided. But while the above discussion is in accord with everyday thought, certain physical phenomena are not in accord with it.

Within the last hundred years, the results of various experiments have forced us from this delightfully simple and "self-evident" relativity. These experiments are of two general types. One type shows that whether we are moving toward, or receding from a ray of light, *it approaches us with the same relative velocity.* From the point of view of classical mechanics this conclusion is little short of astounding, but it is arrived at by direct physical measurement, and must be accepted, at least pending the results of further experimental investigation. It also appears that this is not due to the medium which transmits light (if such there be) being carried along with us as we move.

The other type of experiment shows that the dimensions of particles moving with velocities approaching that of light, vary in a certain way according to the velocity of the system from which they are measured. An electron suffers a contraction in the direction of its motion relative to the system of measurement, and its mass increases as a certain function of its velocity. Computation also shows that, accompanying these transformations, there must be an increase in the units of time on the moving electron, relative to the units on the observing system. These phenomena were known as "The Lorentz-FitzGerald Contraction," and it was first shown by Einstein that they depend not on any peculiarity of electrons, but on the very act of measuring by a means of communication, between object and observer, the velocity of which is invariant.

The revision of the Newtonian principle of relativity to account for these experimentally observed facts has been effected by Einstein in his "Special Theory of Relativity." He has shown that all these phenomena are capable of explanation if we drop the assumption of the invariance of our supposed fundamental physical quantities, and proceed on the assumption of the invariance of the velocity of light. When we do this the stability of our old constants flies to the winds. The length of our trolley car becomes shorter when it is in motion relatively to us than when it is stationary, and the passenger's embonpoint suffers even more so, provided he is walking towards the front of the car; also his velocity over the ground is a little less than the sum of his walking speed and the speed of the car. The equations of this transformation which take the place of (1) and (4) in the Newtonian theory are

$$x' = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}\left(x - vt\right) \tag{5}$$

and

$$t' = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}\left(t - \frac{v}{c^2}x\right), \tag{6}$$

In this transformation none of the properties considered under the former transformation holds, with the exception of (*e*). The point that might be characterized as "revolutionary" is that the space and time transformations are not independent. Now it is true that in previous physical theory four independent coördinates have been used to describe an event, three to establish a position in space, and one to signify the time of that position; but the distinction between space and time has always been definite. The characteristics of space remained invariant in time, and those of time were invariant in space. Under such conditions it was of no utility to complicate the discussion by saying that an event was specified by four coördinates in a four-dimensional space-time, although this conception could have been used by any one so inclined. The sense in which this conception is used in the theory of relativity is, however, far more fundamental.

Consider, for instance, our observation of a cube. Disregarding the effect of binocular vision, a cube may appear to us as a variety of plane figures, according to our line of sight. From one position it appears as a square, from another as an hexagon with three lines from alternate vertices to the center. It may also appear in irregular shapes, with varying lengths of edges and different angles. We further observe that these shapes change as we change our position relative to the object under observation. Now we might formulate a set of laws which would tell us how this plane figure alters its size and shape as we observe it from different distances and directions, but they would appear rather complicated and arbitrary. Equations (5) and (6) are laws so formulated. However, with a certain amount of mathematical insight, we might postulate a three-dimensional object which is *invariant* to the transformations caused by observing it from different directions, namely the cube, and say that the variety of plane figures we see are views of this invariant object from different directions. Equations (5) and (6) say just this, except that the four-dimensional space-time in which we view the phenomena from different angles, depending on our velocity relative to the phenomena, is not Euclidean. It is homaloidal, and may be made to correspond to a Euclidean space of four dimensions by substituting for time a variable proportional to it, but whose square is negative. In mathematical analysis such a variable is technically termed "imaginary," and the use of "imaginary" in this sense is responsible for Mr. Turner's statement that " . . . the 'four-dimensional world of Minkowski' is not a universe which is more truly real than the spaciotemporal world of perceptual experience." The use of the "imaginary" in this connection is entirely unnecessary, and is indeed only a mathematical artifice to simplify certain aspects of the theory, just as certain vectors are represented by complex numbers which have an "imaginary" part, in computations involving alternating currents. We may say that Minkowski's world is Euclidean and four-dimensional, but that our sense of perception of the fourth dimension as time can not perceive it in kind with the other three dimensions, but must perceive a different function of it, *i.e.*, $-\sqrt{-1}\,u$, where "u" is in kind with the three spacial dimensions, or we may say that we perceive all four dimensions as similar in kind, and that Minkowski's world is non-Euclidean. In either case the percept-concept is non-Euclidean, and the argument has the metaphysical possibilities of the question as to whether we are looking up if we are standing on our heads and looking down. The four-dimensional world is more real than the spatial world of three dimensions in exactly the same sense that the cube is more real than the multitude of variously shaped plane figures we observe when looking at it from different positions. It is the invariant that we are compelled to regard as fundamental in seeking that interpretation of results which involves the least number of arbitrary assumptions. In the same sense that it would be exceedingly arbitrary to regard the plane figure which changes size and shape as we change our position, as the fundamental entity, it is arbitrary to regard the figures of spatial points which change shape according to equation (5) as fundamental, when the changes may be perfectly interpreted as a revolution of an invariant in four-dimensional space.

We must, therefore, take direct issue with Mr. Turner's statement that "These methods and principles, however, do not affect in the remotest degree the philosophic problems of objective reality, the pros and cons of which remain what they were before. . . ." Both scientists and philosophers are in danger of falling into a pitfall of verbal quibbles when they attack the question of what is objective. If by "objective" is meant an unknowable reality underlying phenomena, it is hard to see how any physical facts could throw light on the question of such an objective reality. And if by "objective reality" is meant the ordinary perceptual experience of common-sense objects, that is only altered by the Lorentz-FitzGerald contraction, and this would seem to be Mr. Turner's position. But if by "objective" is meant either a rationalized experience, or a world independent of the awareness of a percipient (in the sense in which the neo-realists use independent), such an objective reality is profoundly changed by the "Special Theory of Relativity"; for it transfers the question from the three-dimensional world of spacial points to the four-dimensional world of space-time. In our efforts to narrow the results of physical perception to what appears most likely to be connected with an objective reality, we postulate that it must depend as little as possible on the personality of the observer and the point of observation. This certainly gives the invariant world of four dimensions a stronger position than one composed of three dimensions that vary as we observe them under different conditions; and it would seem that the position hitherto occupied by the three-dimensional cosmos must now be taken by Minkowski's "world" of four dimensions.

Before leaving this part of the discussion I can not refrain from voicing an objection to Mr. Turner's exposition of the transformations in terms of sound. The transformations of the "Special Theory of Relativity" owe their characteristic significance to the invariance of the velocity of light relative to any observer. Mr. Turner's congenitally blind observers could ascertain their velocities relative to the medium which transmits sound, without difficulty, and could also detect the relative velocity of another source of sound. Further, if we grant them a sufficient degree of hyperesthesia, they could detect the Lorentz-FitzGerald contraction, but of course they would not interpret the constant "c" as the velocity of light. Indeed it is not necessary to the special theory of relativity that the velocity of light should be exactly the fundamental invariant velocity "c." The point is that such a maximum exists, and the velocity of light is so close to it that we have as yet detected no difference. For the blind observers to draw Mr. Turner's conclusion that "what is heard is real, and the audible differences in the firing rates of the two guns actual and ultimate," it would be necessary that they be congenitally lacking in other respects than eyesight. Mr. Turner's footnote in this connection regarding the invariance of the velocity of light is analogous to the introduction of the Prince of Denmark as epilogue.

To proceed to the "General Theory of Relativity," it will be recalled that the transformation to a uniformly moving system made no change in the property (*e*), *i.e.*, no forces were introduced into one system that were not in the other, although the question "Uniform relatively to what?" was avoided. Newton saw the difficulty and dodged it by saying in effect, "Relatively to the fixed stars." Now if we try to express the relations between the two systems in such a manner that they are of the same form even though the systems be accelerated, we find that the forces are not invariant, and indeed depend entirely on the way in which we measure the phenomena in question. The general theory states the characteristics of a phenomenon relative to any set of quantities we may choose to measure it by, and shows that the special theory holds only in space free from the effects of gravitating matter. In the presence of gravitating matter the quantities that are invariant are still further reduced, and objective reality in the sense in which three-dimensional objects have been regarded as real becomes still more elusive. The four-dimensional manifold of space-time is not homaloidal, but "curved," and its curvature is determined by an operator called a tensor, whose value for any point is dependent upon the distribution of matter. This curvature must be regarded as having a certain objectivity. By suitably choosing our conditions of observation in any one place, we can remove it locally, as for instance we can lose weight for a few seconds in an elevator that starts to descend, but our elation is short lived, or would be should we get on a pair of scales as the elevator approaches a landing. Removing the effect in one location augments it in the remainder of the continuum.

Among the physical concepts formerly considered fundamental, the only ones that still remain invariant are the concept of "action," which is of the dimensions of energy times time, and the thermodynamic function, "entropy." From the new standpoint, qualities that we have hitherto regarded as theoretically being able to increase without limit, are definitely limited. Thus we have a maximum velocity "*c*," and a definite extent of space which may be computed as a function of the mean density of matter. There also appears to be an upper limit to the density of matter or energy. These results are due, not as Mr. Turner says in concluding "to the fundamental rôle, already alluded to, played by light and vision in normal experience," but to the discovery that there is a fundamental velocity that is invariant, and which happens to be very near the velocity of light; so near in fact that the two are quite generally regarded as identical. My reason for stating it in this way is to emphasize the point that is *not* the fact that this velocity is that of light, but that it is *invariant* that leads to the theory of relativity.

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NEWPORT NEWS, VA.

AN HISTORICAL ANTICIPATION OF JOHN FISKE'S THEORY REGARDING THE VALUE OF INFANCY

JOHN FISKE is universally credited, and justly, with making an important contribution to the theory of evolution. I refer to his theory regarding the meaning and value of the prolonged period of human infancy in comparison with the briefer infancy of the lower animals. Without questioning Fiske's independence of other sources in developing his theory, I would like to call attention to an obscure essay published nearly forty years before Fiske's first book appeared, an essay in which the two points regarding the value of infancy made by Fiske are made in a strikingly parallel manner.

A few months ago Mr. George W. Robinson, Secretary of the Harvard Graduate School, showed me an old volume which he had found in a second-hand book-store; and he called my attention to an essay in it which, as he thought, was similar to writings by Fiske many years later. This volume is entitled *The Friend's Annual; or Aurora Borealis.* It consists of essays written by "Members of the Society of Friends" and was published in England in 1834. Among the essays is one covering six pages (pp. 152–57) entitled "On the Helpless State of Infancy," which is signed simply with the initials, V. F.

The purpose of V. F., writing before the acceptance of evolutionary views, was to show the "graciousness of Providence" in establishing the long period of helpless human infancy. The purpose of Fiske was to support the evolutionary theory by showing the significance of a lengthened infancy as a factor in bridging the gap between brute and man, and to account for the evolution of human intelligence and morals. Indirectly, however, Fiske was attempting to "justify the ways of God to man" by pointing out the goodness of the Power manifested in the evolutionary process, and for this reason the similarity between Fiske's theories and V. F.'s become all the more striking. According to Fiske, as is well known, a long period of infancy is valuable, first, in giving time for educative influences to work upon the plastic brain and in making